Report for 2001PA721G: Enrichment, biochemical, and molecular techniques for assessing microbial arsenic reduction

- Book Chapters:
  - Santini, J.M. and J.F. Stolz. 2004. Prokaryote arsenate and selenate reduction. In M.S. Nakano and P. Zuber (eds.) Strict and facultative anaerobes: Medical and environmental importance. Horizon Scientific Press (in press).
- Other Publications:
  - Poster Presentation: E. Fisher, A. Dawson, J. Kisak, G. Polshyna, P. Basu, and J.F. Stolz. 2003. Enrichment, isolation, and characterization of a Clostridium species that respires arsenate and selenite ASM General Meeting, Washington, DC, May 18-22, 2003.
  - Poster Presentation: E. Afkar, C. Saltikov, J. Lisak, P. Basu, R.S. Oremland, and J.F. Stolz. 2003. Purification and characterization of the respiratory arsenate reductase from Bacillus selenitireducens. ASM General Meeting, Washington, DC, May 18-22.
  - Poster Presentation: J.F. Stolz, E. Afkar, J. Lisak, C.Saltikov, R.S. Oremland, and P. Basu. 2003. The respiratory arsenate reductase from the Haloalkaliphile Bacillus selenitireducens: A Molybdoenzyme that functions at high pH and salinity. Gordon Research Conference, Kimball Union Academy, June 29-July 4, 2003.
  - Invited Presentation: Gordon Conference on Molybdenum and Tungsten Enzymes, Kimball Union Academy, Meriden, NH, July 3, 2003.
  - Symposium: Arsenic dynamics within soils and sediments, American Society of Agronomy, Crop Science Society of American, and Soil Science Society of American annual meeting, Denver, CO, November 3, 2003.
  - Departmental Seminar: Geosciences Department, Virginia Polytechnic Institute and State University, (Microbial transformation of arsenic), April 26, 2004.
- Articles in Refereed Scientific Journals:
  - Stolz, J.F., P. Basu, and R.S. Oremland, 2002. Microbial transformation of elements: the case for arsenic and selenium. Int. Microbiol. 5:201-207.
  - Afkar, E., J. Liska, C. Saltikov, P. Basu, R.S. Oremland, and J.F. Stolz. 2003. The respiratory arsenate reductase from Bacillus selenitireducens Strain MLS10. FEMS Microbiol. Letts. 226:107-112.
  - Oremland, R.S. and J.F. Stolz. 2003. The ecology of asenic. Science. 300:939-944.
  - Oremland, R.S., J.F. Stolz, and J.T. Holligaugh. 2004. The microbial arsenic cycle in Mono Lake, CA. FEMS Microbiol. Ecol. 48:15-27.
  - Hoeft, S.E., T.R. Kulp, J.F. Stolz, J.T. Hollibaugh, and R.S. Oremland. 2004. Dissimilatory arsenate reduction with sulfide as the electron donor: Experiments with Mono Lake water and isolation of strain MLMS-1, a chemoautotrophic, arsenate-respirer. Appl. Environ. Microbiol. 70:2741-2747.

Report Follows

PROBLEM AND RESEARCH OBJECTIVES:

Use of micron filtration for treatment of water and wastewater is growing rapidly. In many installations, operators have required the post-design application of coagulants in order to achieve the design water production rtes. However, strategies for in-line coagulation / micron filtration had not been established. This project addressed the use of coagulants for micron filtration. The objectives were to determine the coagulation conditions that could result in low trans-membrane pressures (TMP), long operation between chemical in-place cleaning (CIP), and removal of contaminants such as natural organic materials.

METHODOLOGY:

The research involved bench-scale testing at Penn State and collaboration with membrane vendors and membrane users for field applications. The major independent variables for both bench-scale and pilot-scale testing were total organic carbon (TOC) concentration, coagulant type, coagulant dose, pH, zeta-potential of the resulting solids, permeate flux and other operating conditions.

A bench-scale Pall Microza microfiltration unit was used for tests on water from the Susquehanna River near Duncannon PA. The objective was to determine appropriate coagulation conditions so that membrane filtration would produce a finished water in compliance with the Enhanced Surface Water Treatment Rules, especially regarding the need to remove at lest 35% of TOC. The focus of these experiments was to determine the effect of coagulation on water quality and therefore experiments were run at the relatively low permeate flux of 50 gal/day/ft^2 (gfd). The same experimental set-up was subsequently used for other synthetic and natural waters.

In other bench-scale experiments, flat membranes were used in recirculated-batch experiments, and permeate flux was regularly increased from about 10 gfd to about 180 gfd. Various coagulation conditions were tested. The rate of increase of trans-membrane pressure (TMP) with permeate flux was used to estimate the “critical flux”, i.e. the permeate flux at which rapid fouling of the membrane occurred. Water quality was also determined for each coagulant and permeate flux condition.

Pilot-scale and full-scale field tests were performed at Duncannon PA and other locations, in collaboration with consultant and municipal partners.

PRINCIPAL FINDINGS:

Addition of coagulants improved removals of contaminants and also resulted in decreased TMP for a given permeate flux. Low solids loading was achieved through manipulation of pH as well as selection of the best coagulants for each water supply. Aluminum chlorohydrate was universally effective, while alum, ferric chloride, and polyaluminum chlorides were very effective coagulants for some waters and were poor coagulants for other waters. Coagulants were effective even when the conditions were inappropriate for conventional water treatment practices, i.e. when the zeta potential and coagulant dose prohibited formation of solid phases that could be removed by conventional clarifiers and rapid filters. Bench-scale results accurately predicted pilot-scale performance, especially for removal of contaminants such as TOC and manganese.

Application of the bench-scale results to full-scale membrane facilities resulted in decreased TMP for the design flux.

Students Supported: Young-June Choi, Environmental Engineering, Ph.D.

Presentations and Other Information Transfer Activities:

Dempsey, B.A. "Small System Compliance Technology", 2001 PA Rural Water Association Annual Conference, University Park, PA, March 29, 2001.

Choi, Y., In-line Coagulation with Micron Filtration, ACS Colloid & Surface Science Symposium, Carnegie Mellon University, June 10-13, 2001, Pittsburgh, PA.

Dempsey, B.A., Use of Coagulants with Membrane Filtration, invited presentation at Southern Ionics, Inc., October 1-2, 2001, Columbus, MS.

Dempsey, B.A. "Micron Filtration for Potable Water and Wastewater", Presented at VPI&SU, Department of Civil & Environmental Engineering, Blacksburg, VA, November 2, 2001.

Choi, Y., 'Searching for Cleaner Drinking Water: In-line Coagulation with Micron Filtration', Annual Symposium of the Penn State Center for Environmental Chemisty & Geochemistry, March 22-23, 2002, University Park, PA.

Rosatti, D., and Choi, Y., "Beneficial Reuse of Wastewater using Coagulation and Membrane Filtration", Green Design Symposium of the Penn State Center for Sustainability, April 26-27, 2002, University Park, PA.

Dempsey, B.A. Pre-Conference Workshop on Coagulants and Flocculants, *Intertech Coagulants & Flocculants 2002*, Chicago, IL, May 22, 2002.

Williams, S.G., Wert, J.D., and Dempsey, B.D. Small Treatment Plant Technology in the Face of New Surface Water Treatment and Disinfection Byproduct Rules. Am. Water Works Assn., Annual Conference & Exposition, New Orleans, LA, June 16-20, 2002.

Penn State, Department of Civil & Environmental Engineering, PhD seminar course "Membrane Science and Technology", Spring 2002.

Short course on Membranes for Small Water Systems, in preparation for the PSU-Harrisburg Center for Small Water Treatment Facilities.